

Lightning Research at NASA/MSFC & UAH



Dr. Monte Bateman, WB5RZX



Why is NASA Interested in Lightning?

- Apollo 12 (1969)
- AC-67 (1987)
- First LLCC (1991)
- Operational



How do we Study Lightning?

- Ground-based sensors & networks
- Aircraft-based sensors
- Low-Earth Orbiting satellites
- Geostationary Earth Orbiting satellites

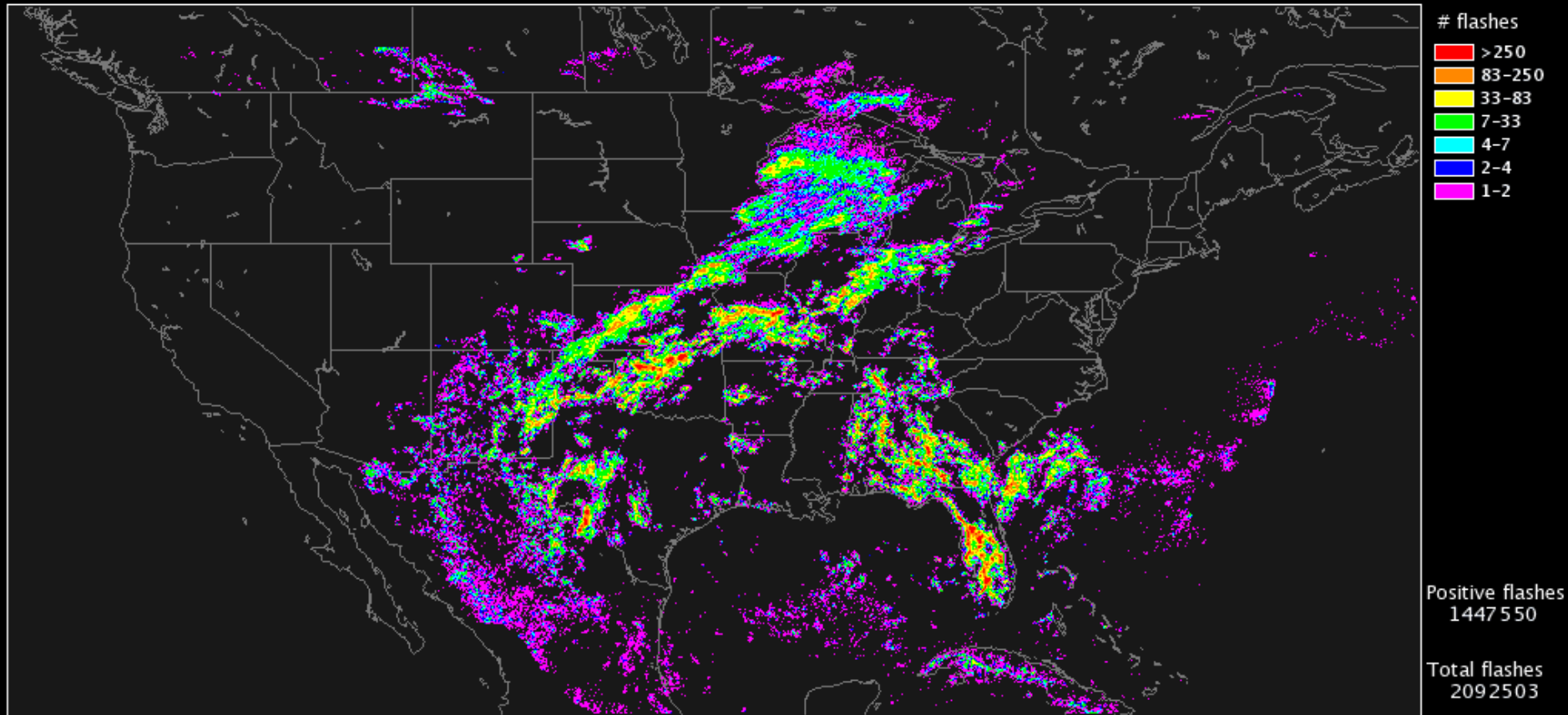
National Lightning Detection Network (NLDN)

- Limited to ground strikes, land-based



26 Jun 2016

U.S. Daily Lightning Summary



Other ground-based sensors

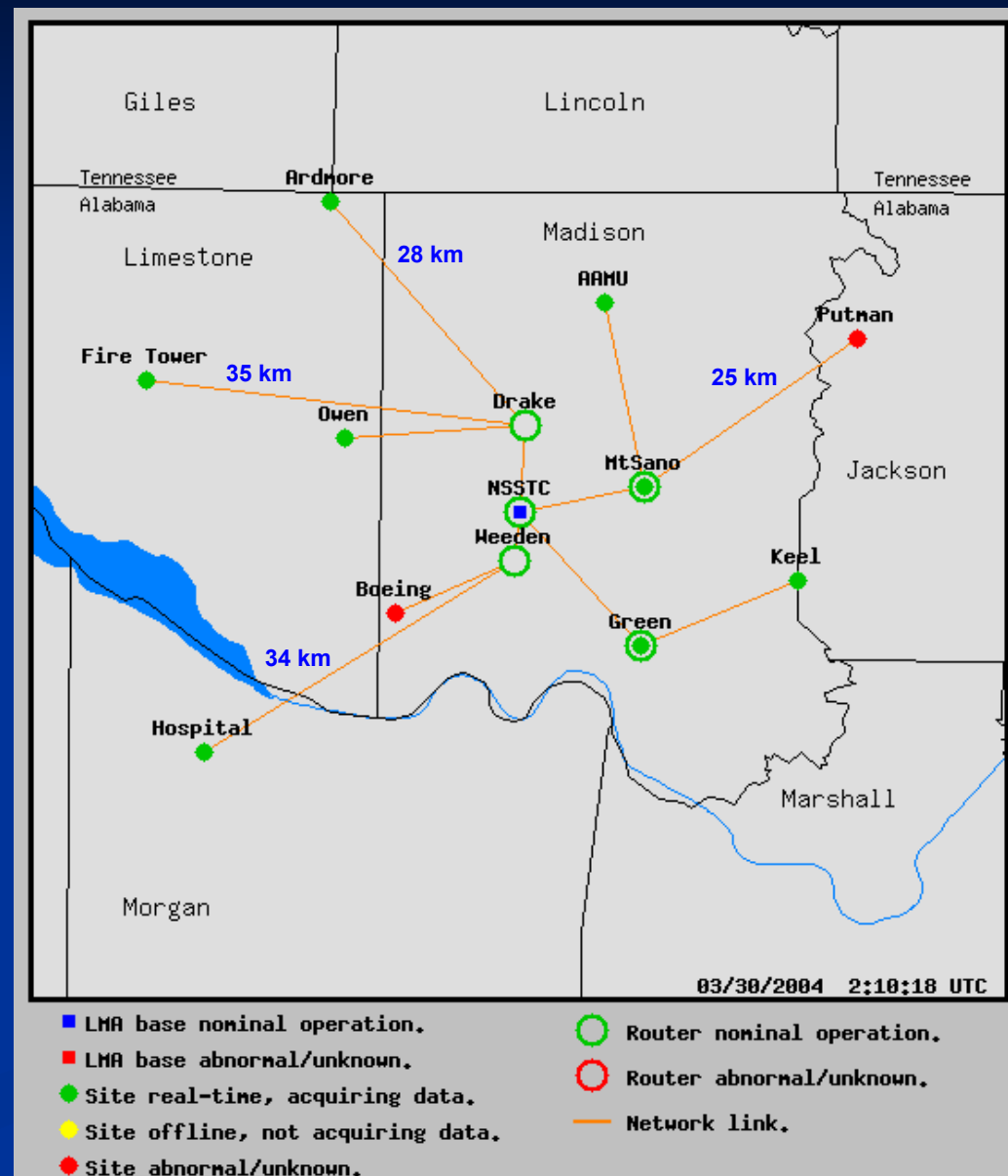
- Earth Networks (Weatherbug) + WWLLN
- GLD360
- Cross-comparison studies

High-resolution ground-based network

- 3-D Lightning Mapping Array (LMA)
 - Senses VHF impulses (60-70 MHz range)
 - Maps an impulse in space and time (GPS)
 - Detects 100–3000 sources per flash
 - Lets us view lightning inside the storm
 - Can study complete storm lifetime
 - HSV was longest running LMA in existence
- Cons
 - Limited in range
 - Limited in national coverage
 - Expensive to maintain

North Alabama LMA Site Map

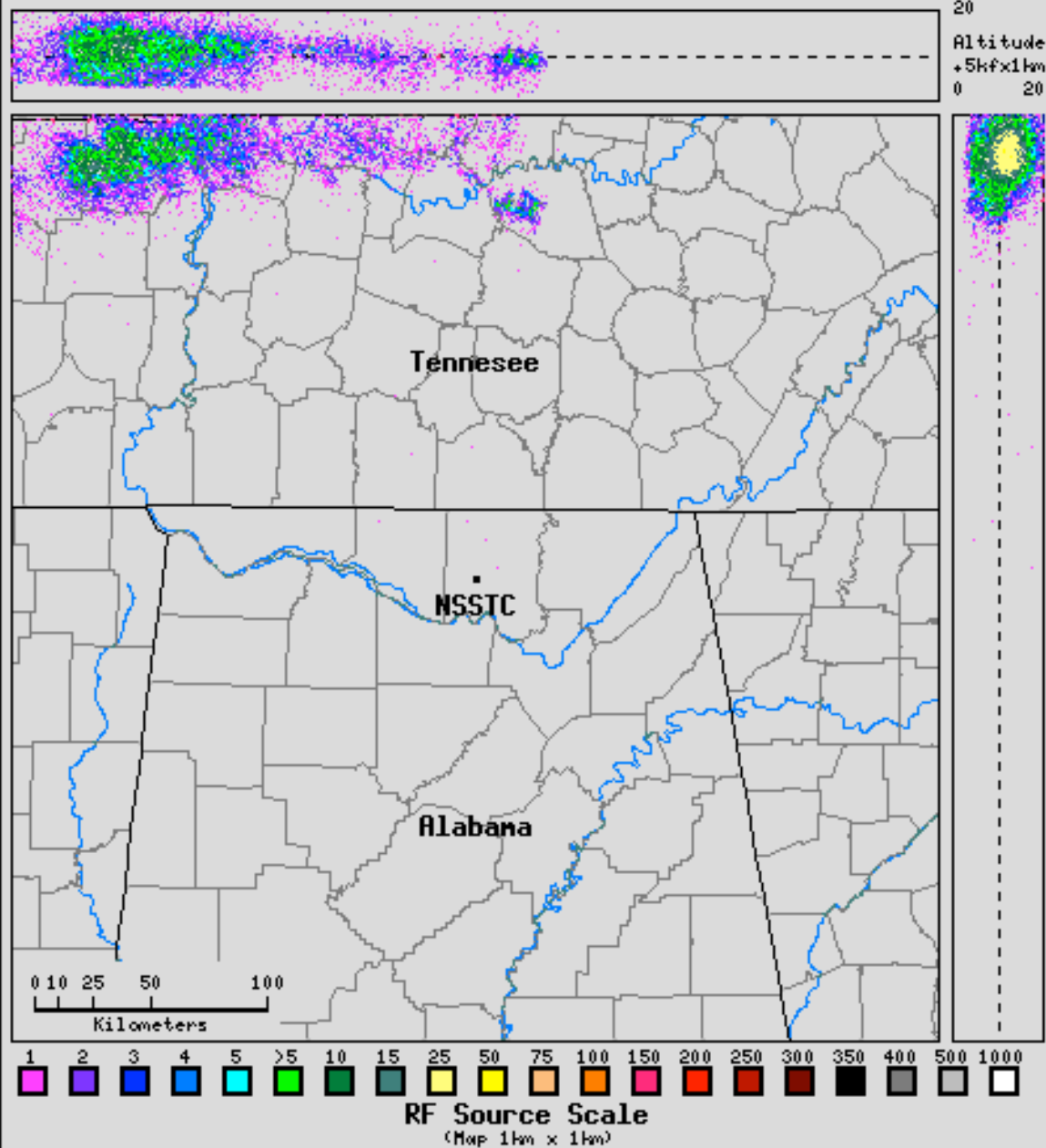
- 10 sensor sites
 - longest link 35 km (22 mi)
 - mean link 20 km (w/ relays)
- 4 relay sites
- NSSTC central facility

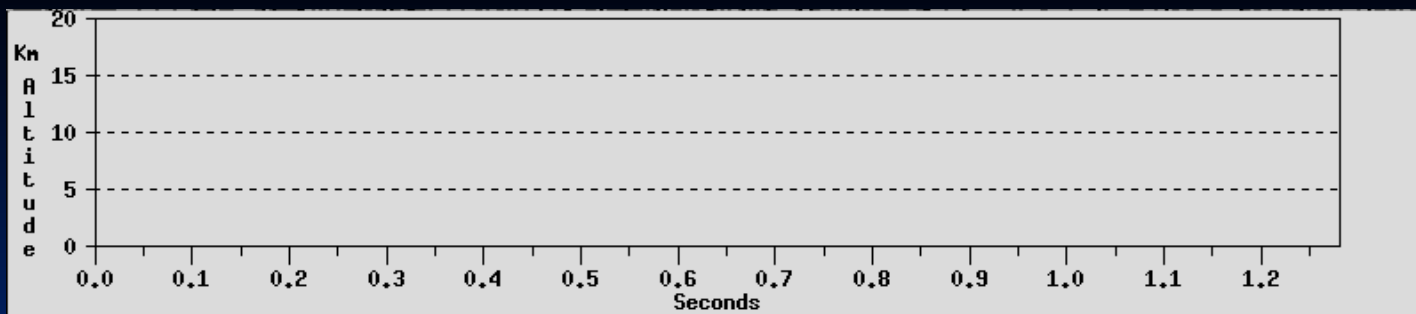


North Alabama Lightning Mapping Array

March 30, 2002

00:00:00 - 00:04:59 UTC



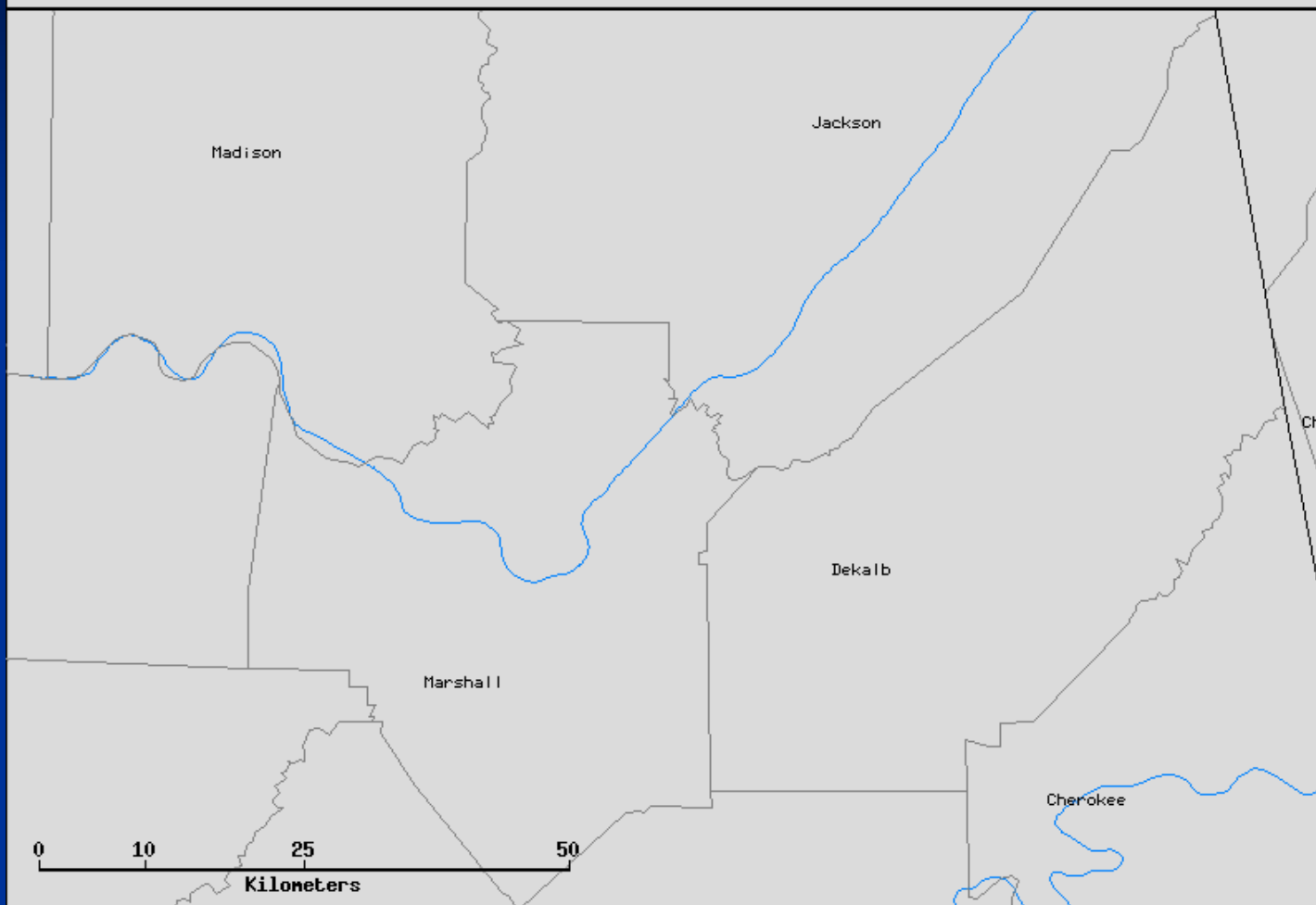
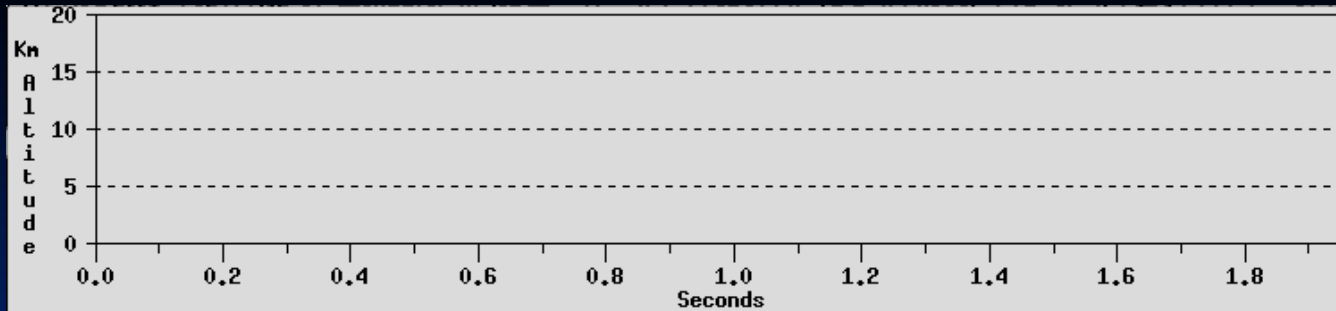


March 30, 2002
08:01:28.345982 - 08:01:29.626182
Duration 1.280200 Seconds
NLON N 2 P 0 LMA 2689

Lightning Mapping Array
0.00000

MSFC



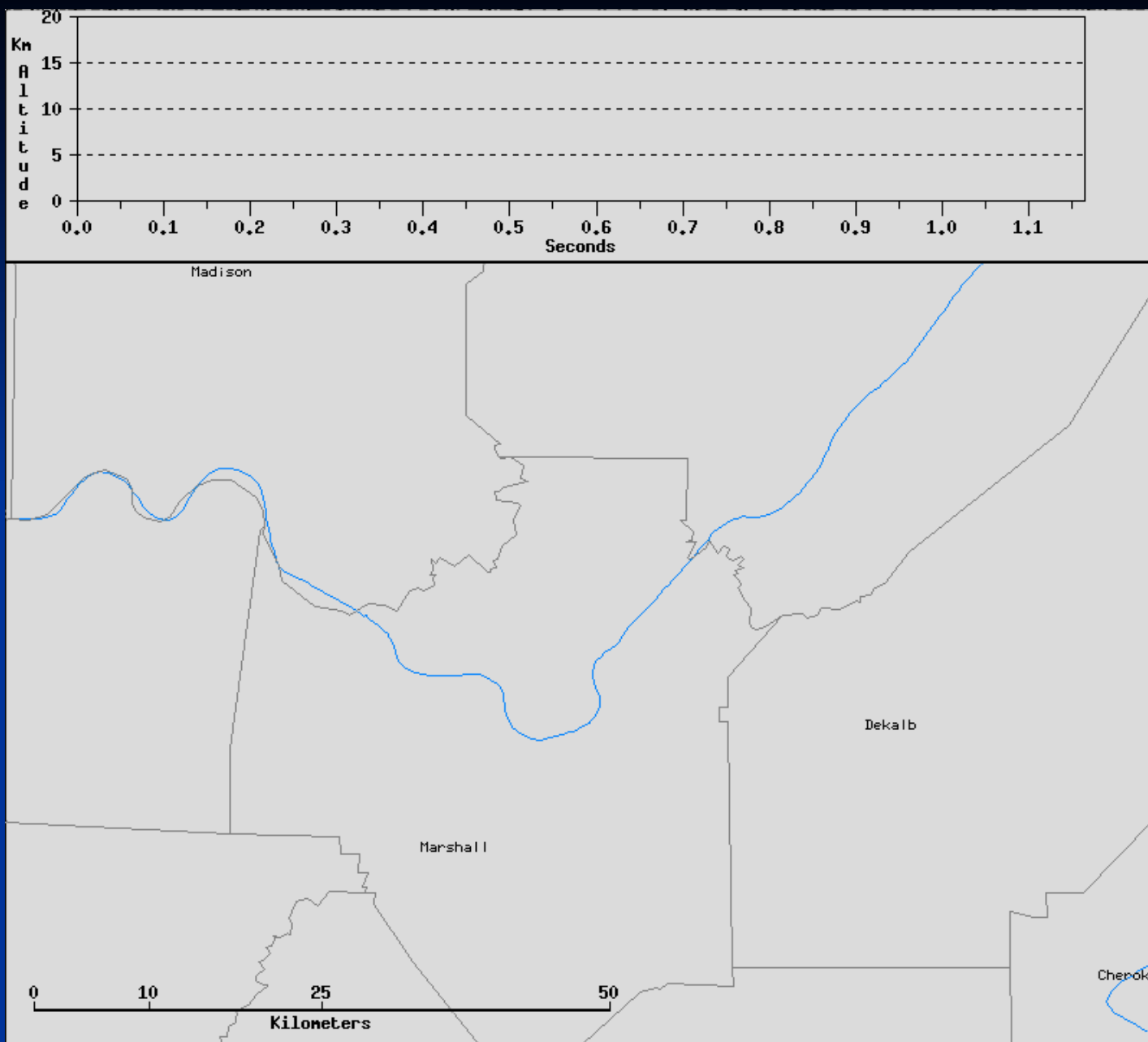


March 30, 2002
08:09:07.035252 - 08:09:08.994192
Duration 1.958940 Seconds
NLDN N 2 P 1 LMA 3721

Lightning Mapping Array
0.00000

MSFC



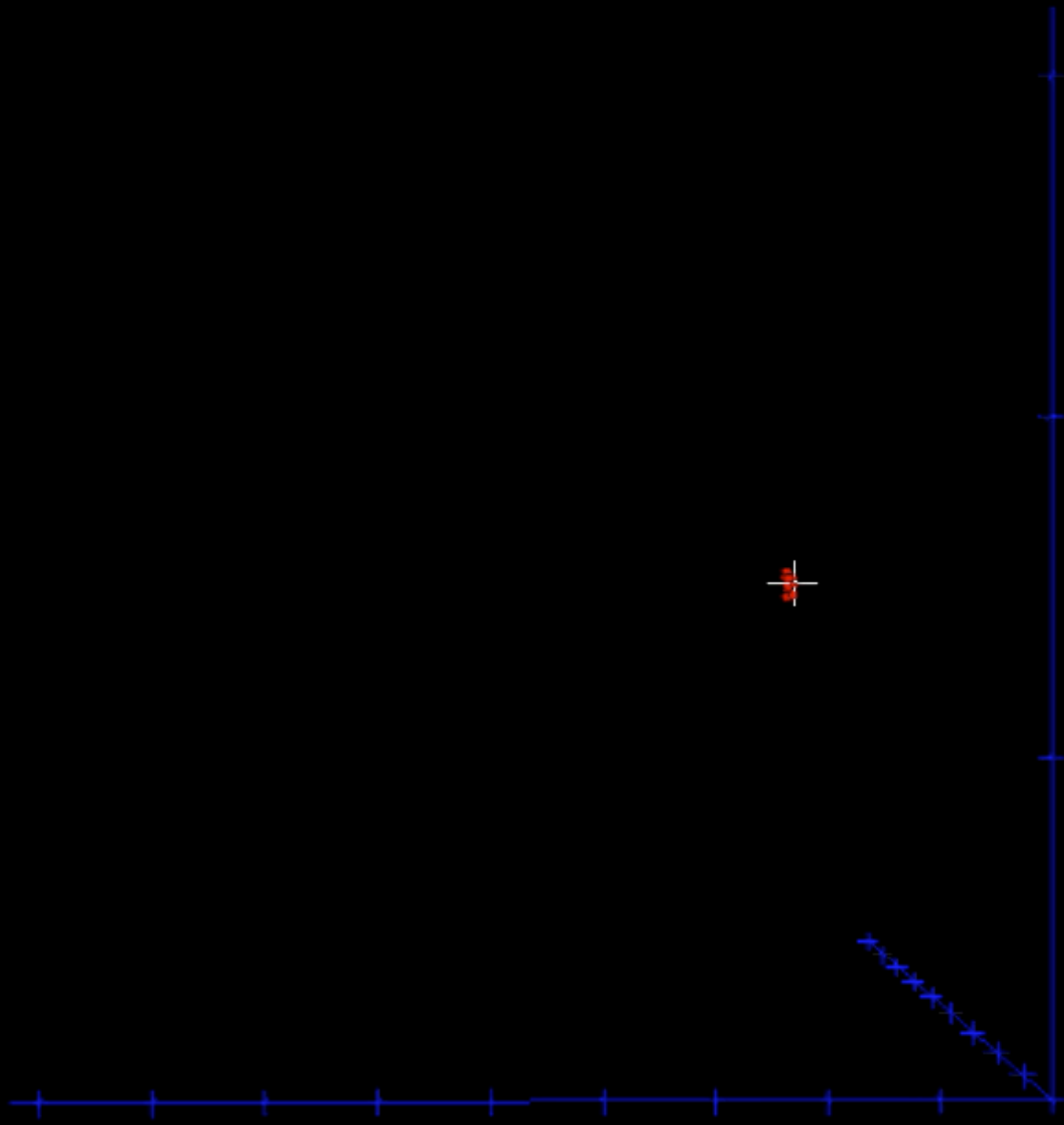


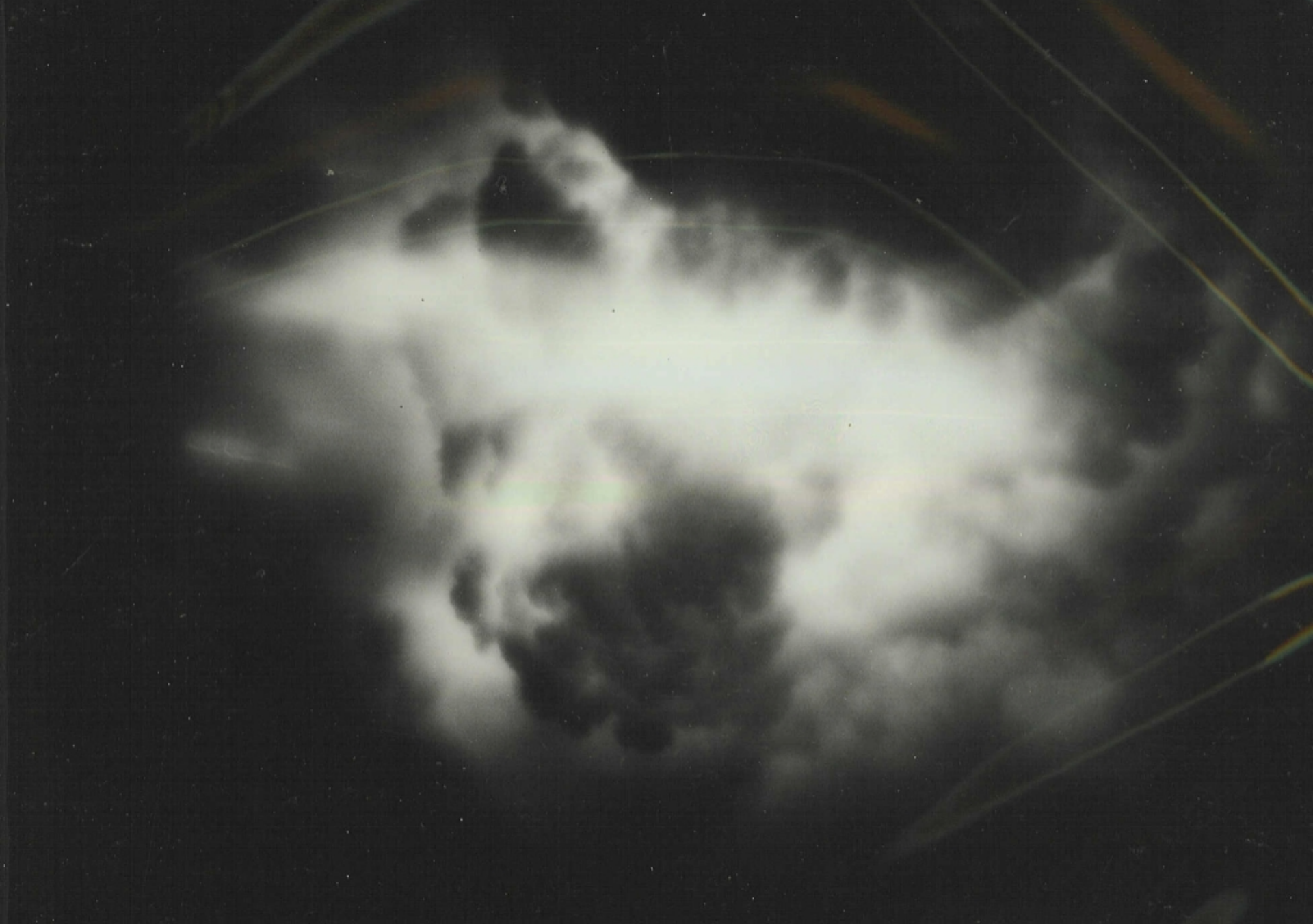
March 30, 2002
08:19:34.836322 - 08:19:35.999642
Duration 1.163320 Seconds
NLDN N O P 1 LMA 2760

Lightning Mapping Array
0.00000

MSFC







from Shuttle (LEO)

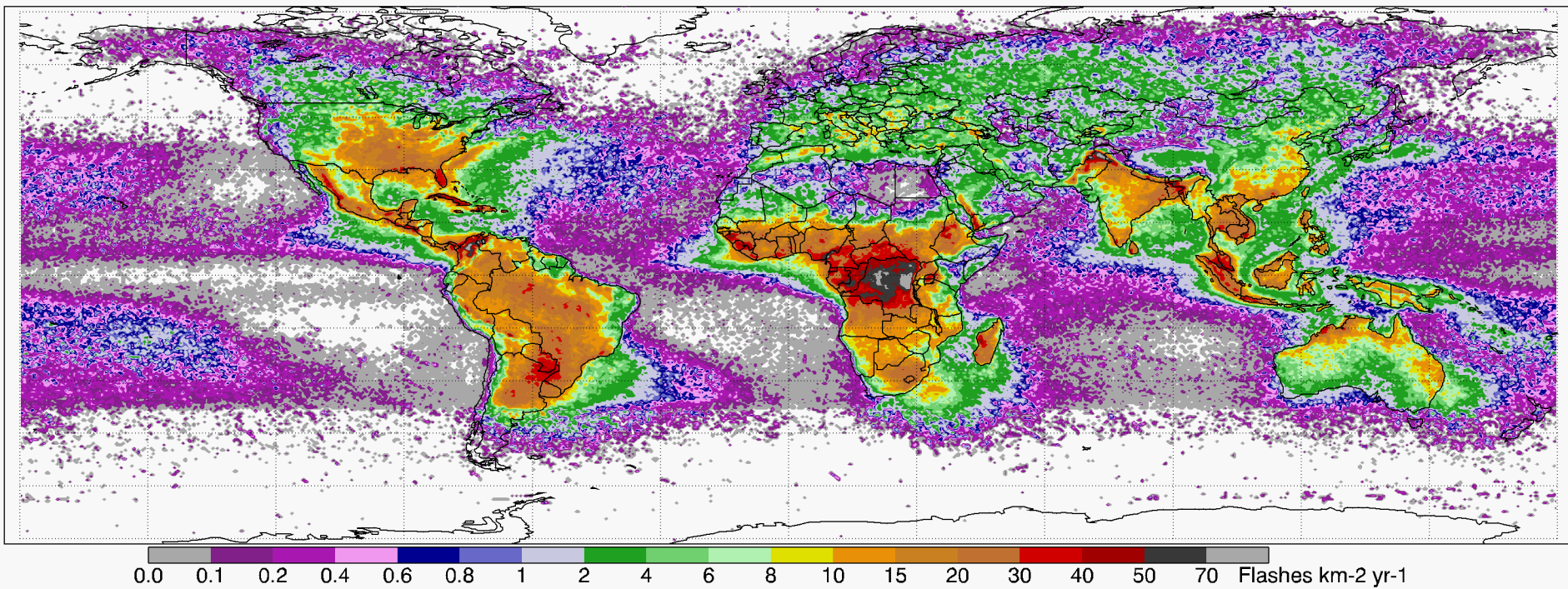
Space-based Lightning Measurements

- Optical (CCD), staring imager
- U-2 flights, lightning spectra (777.4 nm)
- How to see lightning in daytime?
 - Spectral Filtering
 - Temporal Filtering
 - Spatial Filtering

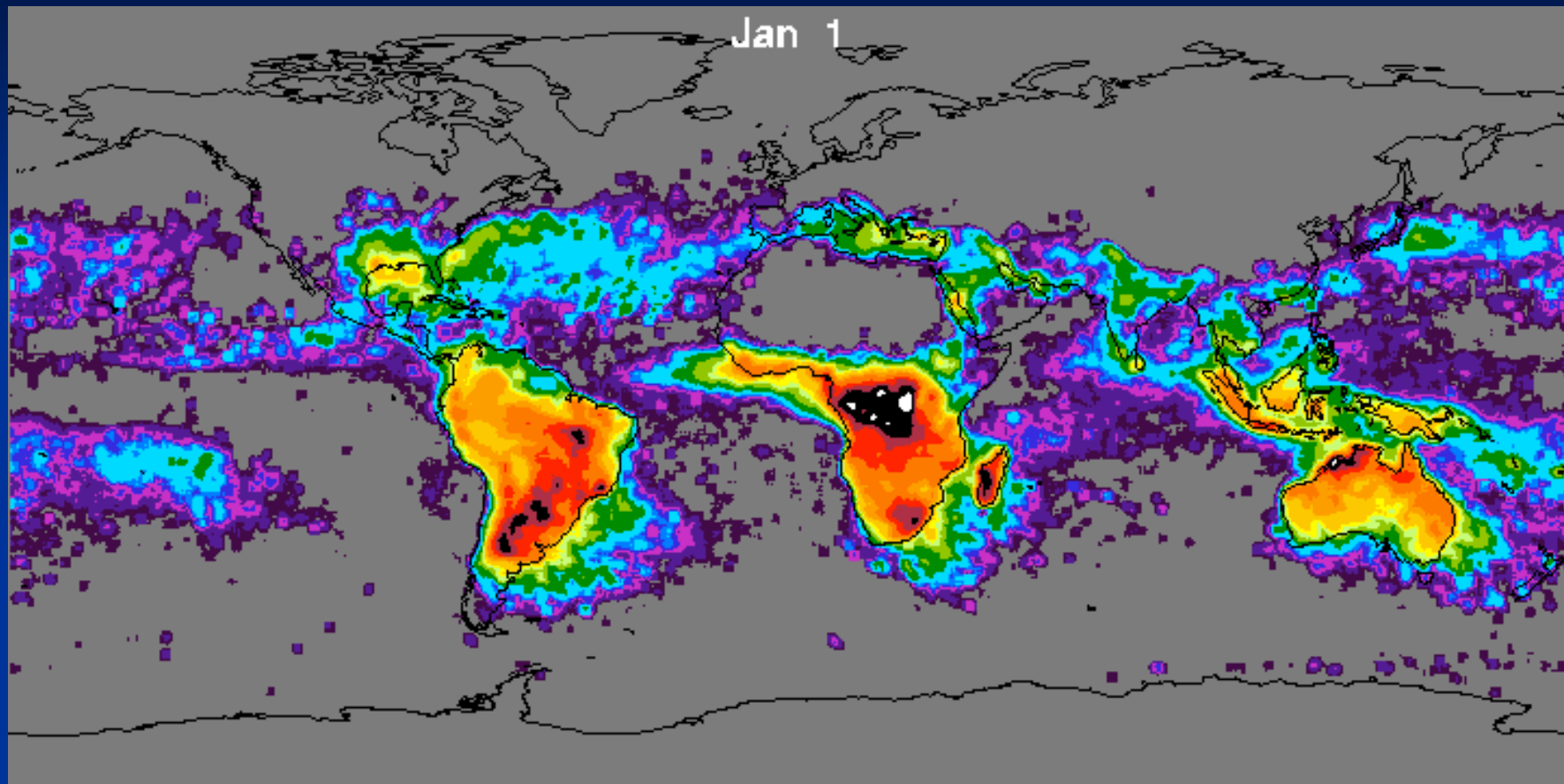
Low Earth Orbiting (LEO) Satellites

- OTD/LIS (250 mi)
- Detects cloud and ground (total) lightning
- Time over storm ~ 80s
- Takes many orbits to cover the Earth
- Cannot study individual storms
- Can do lightning climatology
- LIS – Launched Nov 1997 for 3 yrs
- Splashed June of 2015!

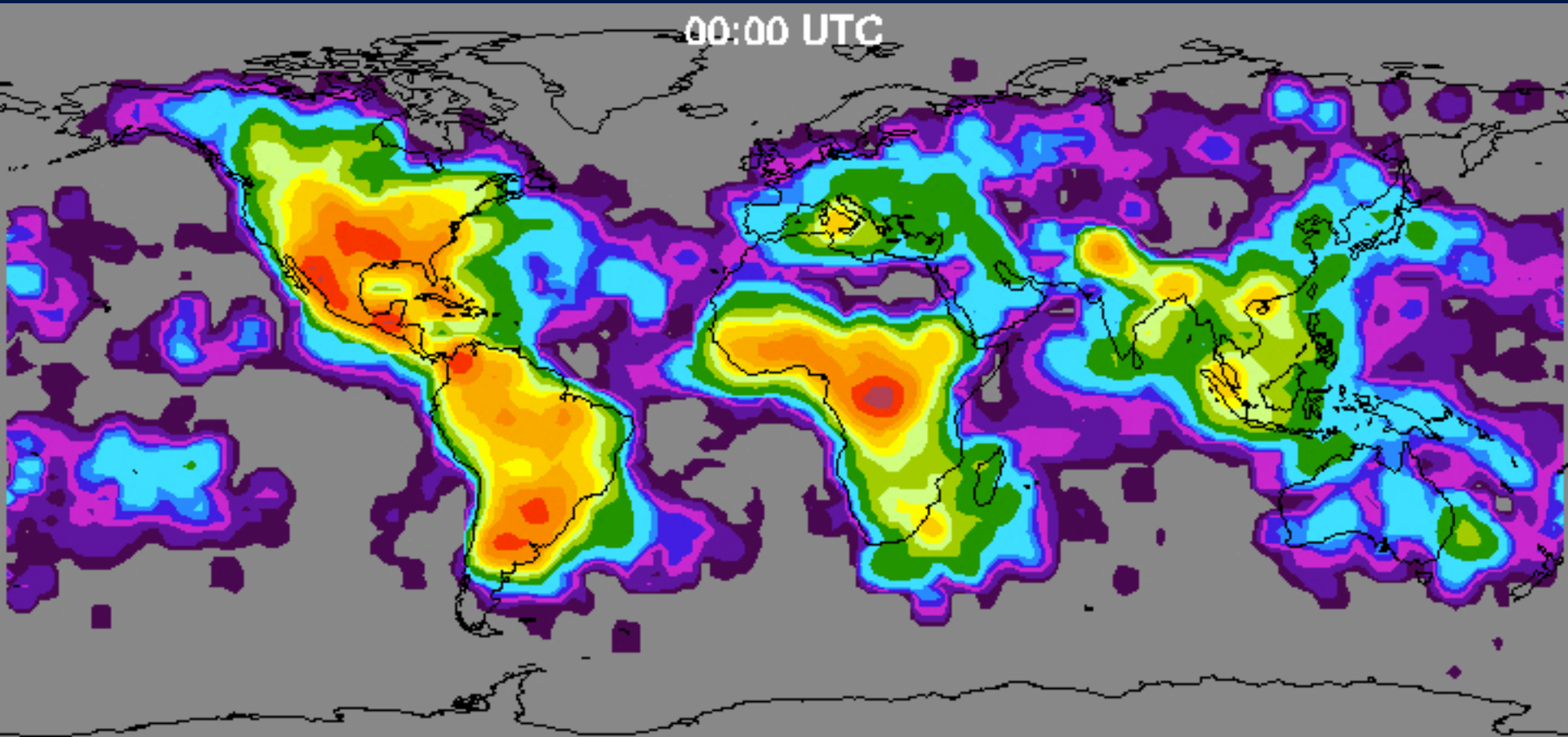
High Resolution — Annual Flash Rate May 1995 -- 2010



Jan 1



00:00 UTC

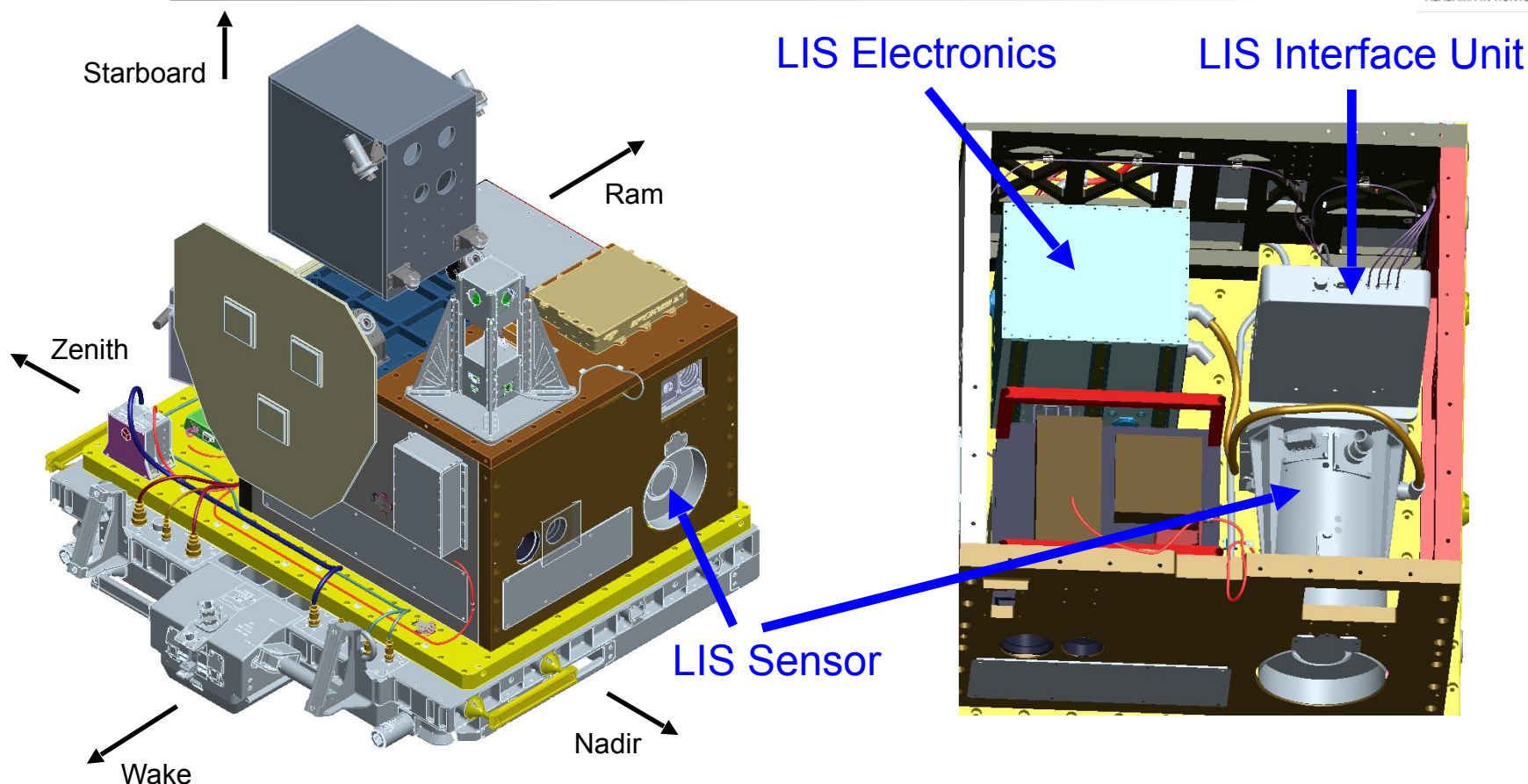


ISS-LIS

- LIS spare, launched to ISS Jan 2017
- Carried by a Space-X Dragon
- Hardware & software done here
- Is providing continued LIS data stream
- Useful to cross-compare with GLM



LIS Integration as Hosted Payload on STP-H5



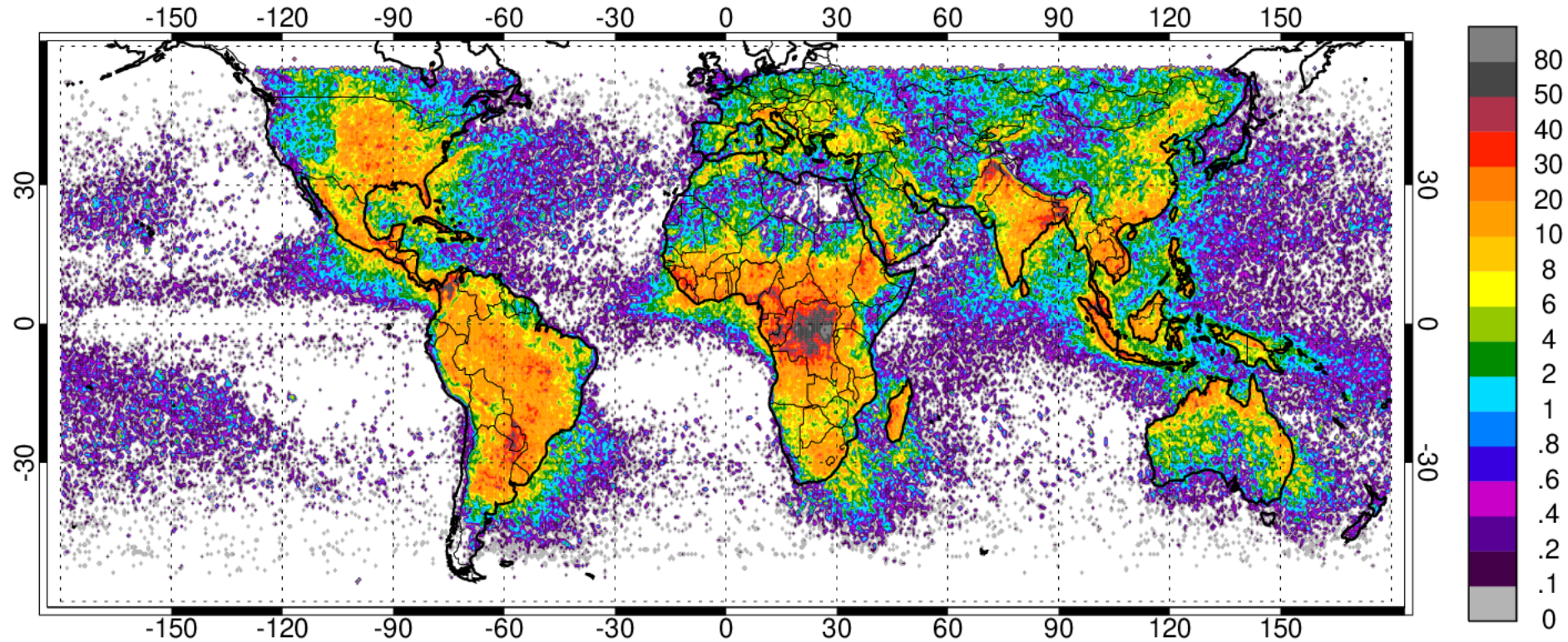
- LIS is one of thirteen instruments on the STP-H5 payload manifest.
- LIS will be installed on ISS in an Earth viewing (nadir) position.
- Payload built on special structure to allow robotic installation on ISS.





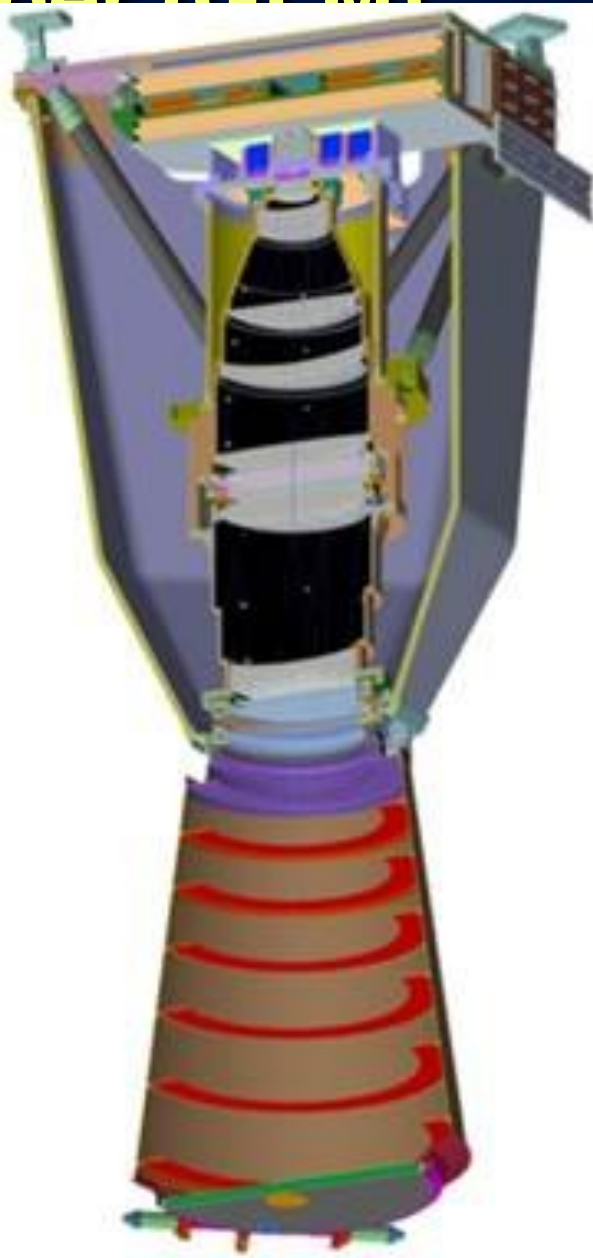
Annual Global Flash Rate Density

Mar 2017 - Feb 2021 0.5° ISS LIS Lightning Climatology (Flashes $\text{km}^{-2} \text{yr}^{-1}$)

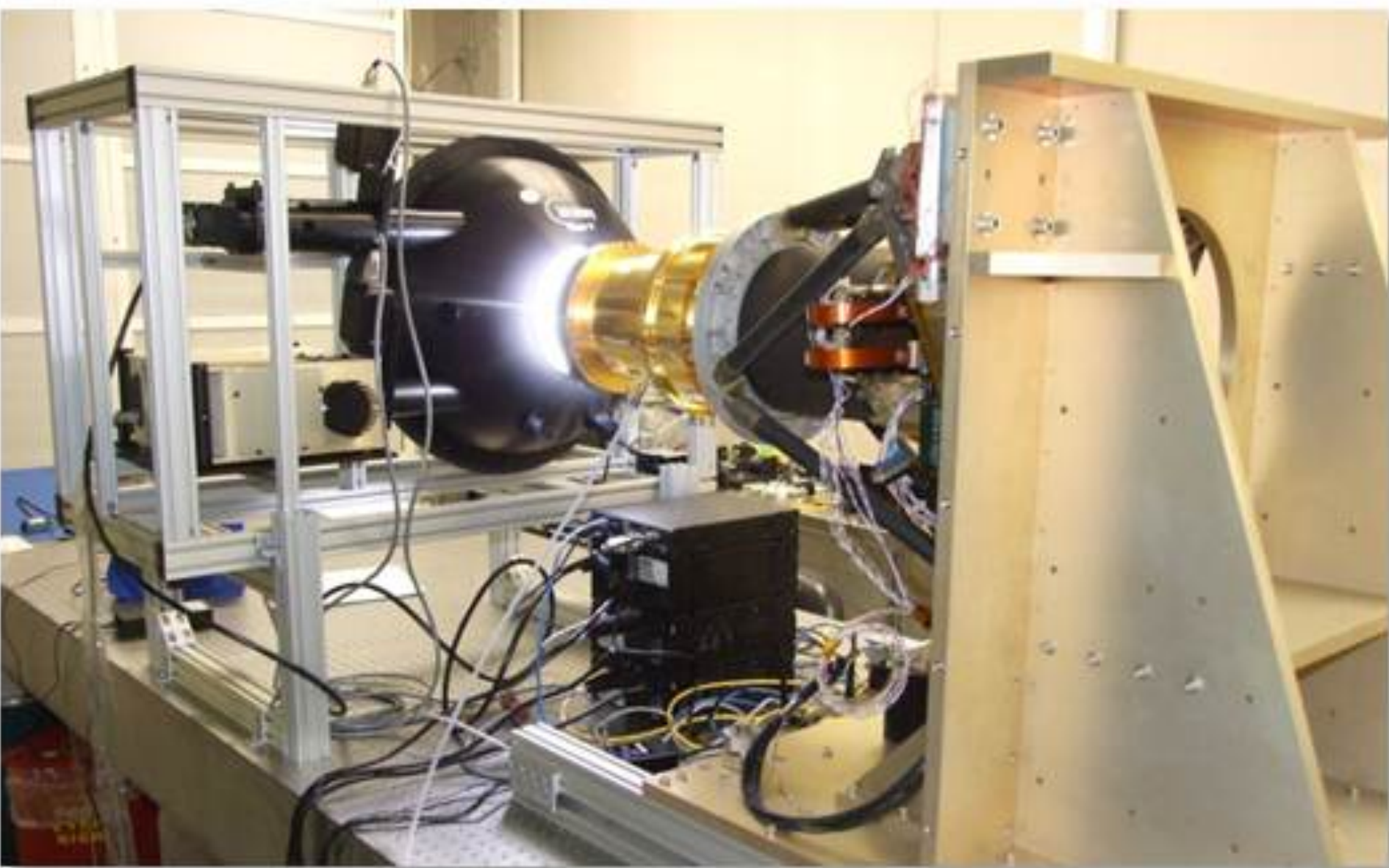


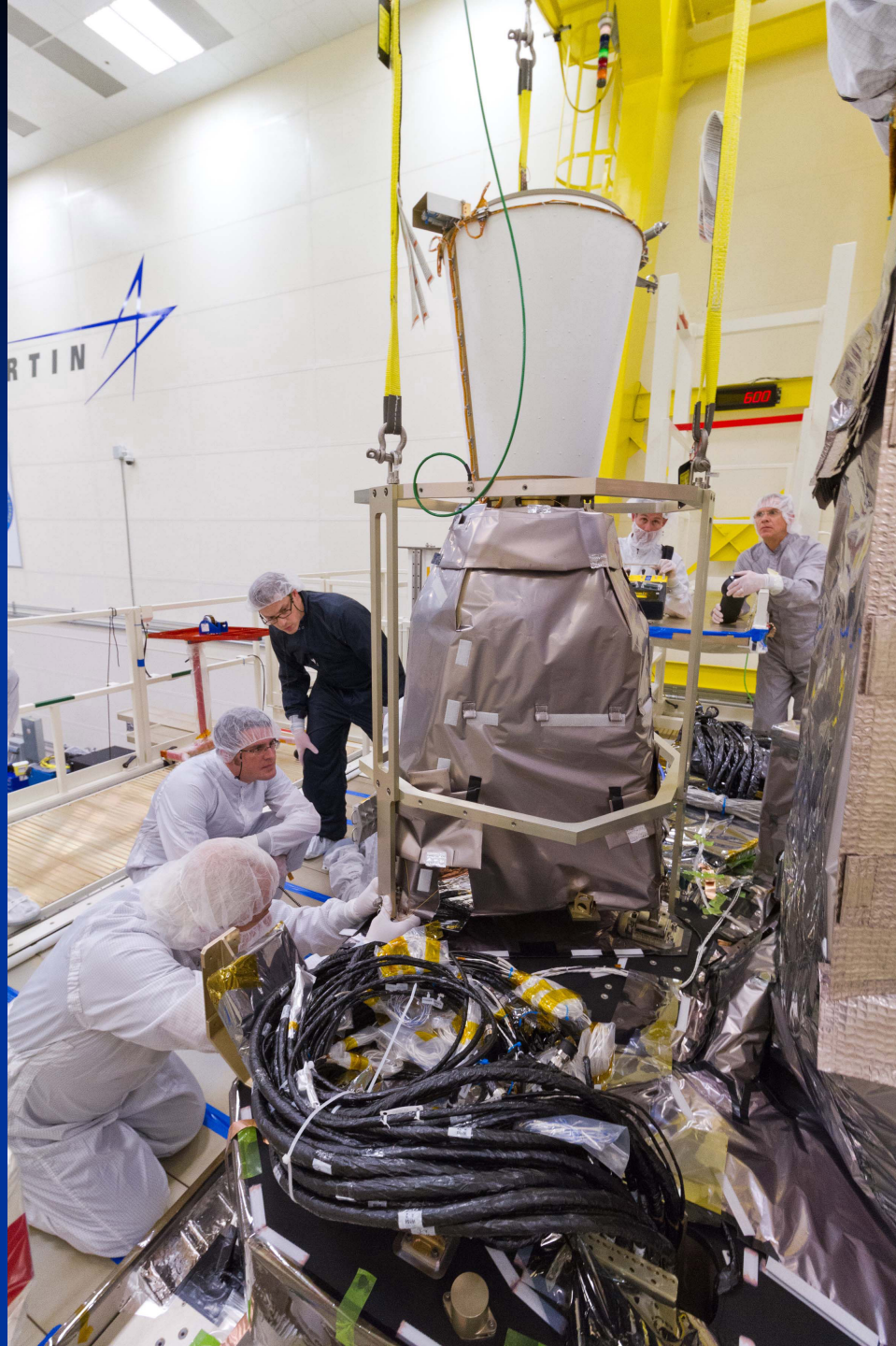
Geostationary Lightning Mapper (GLM)

- GEO orbit (22,500 mi)
- Hemisphere coverage
- Onboard GOES-R (Nov 2016)
- Onboard GOES-S (Mar 2018)
- Onboard GOES-T (Mar 2022)









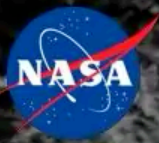
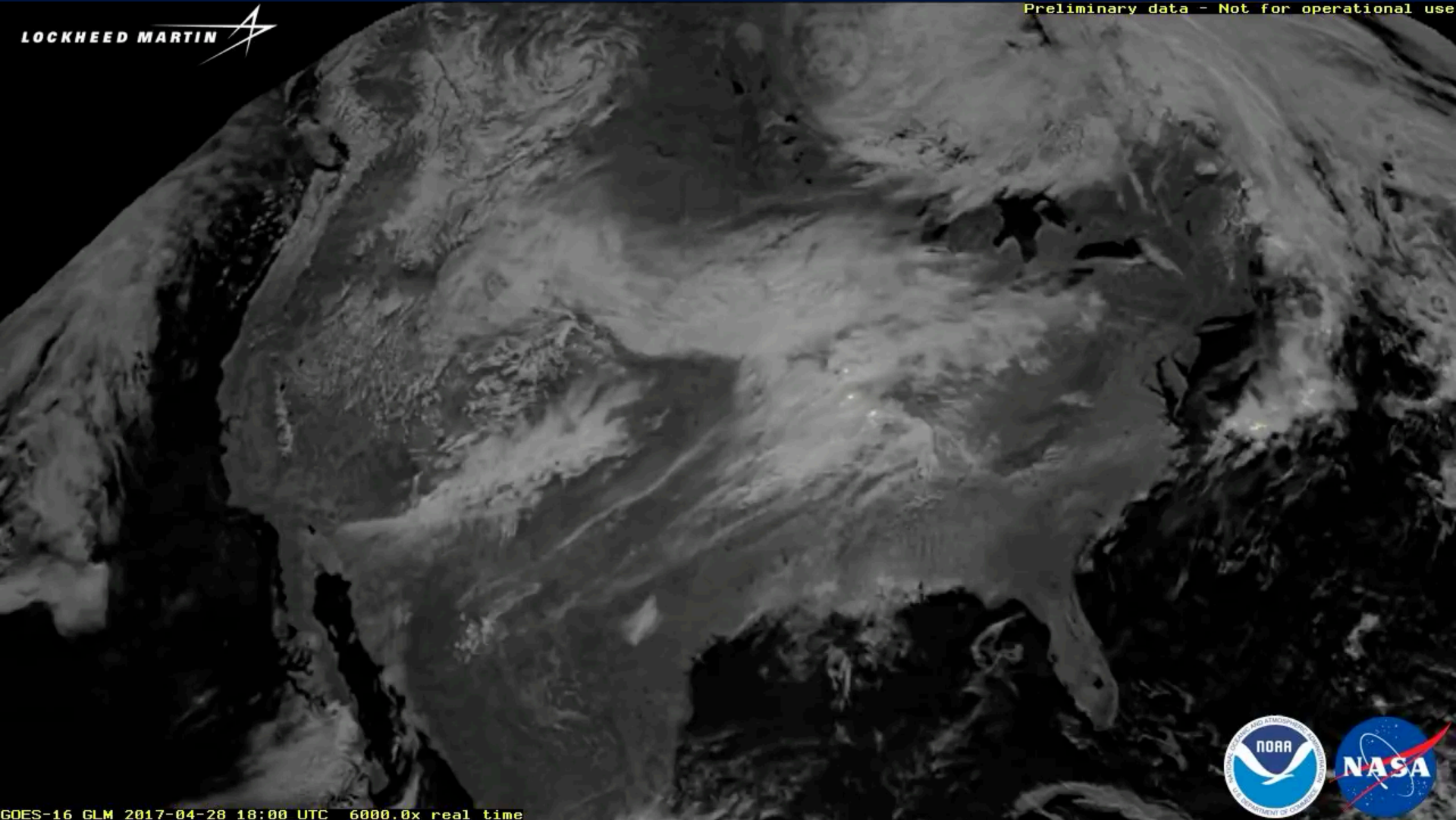
GOES-R (16)



Apr 28-30, 2017



Preliminary data - Not for operational use

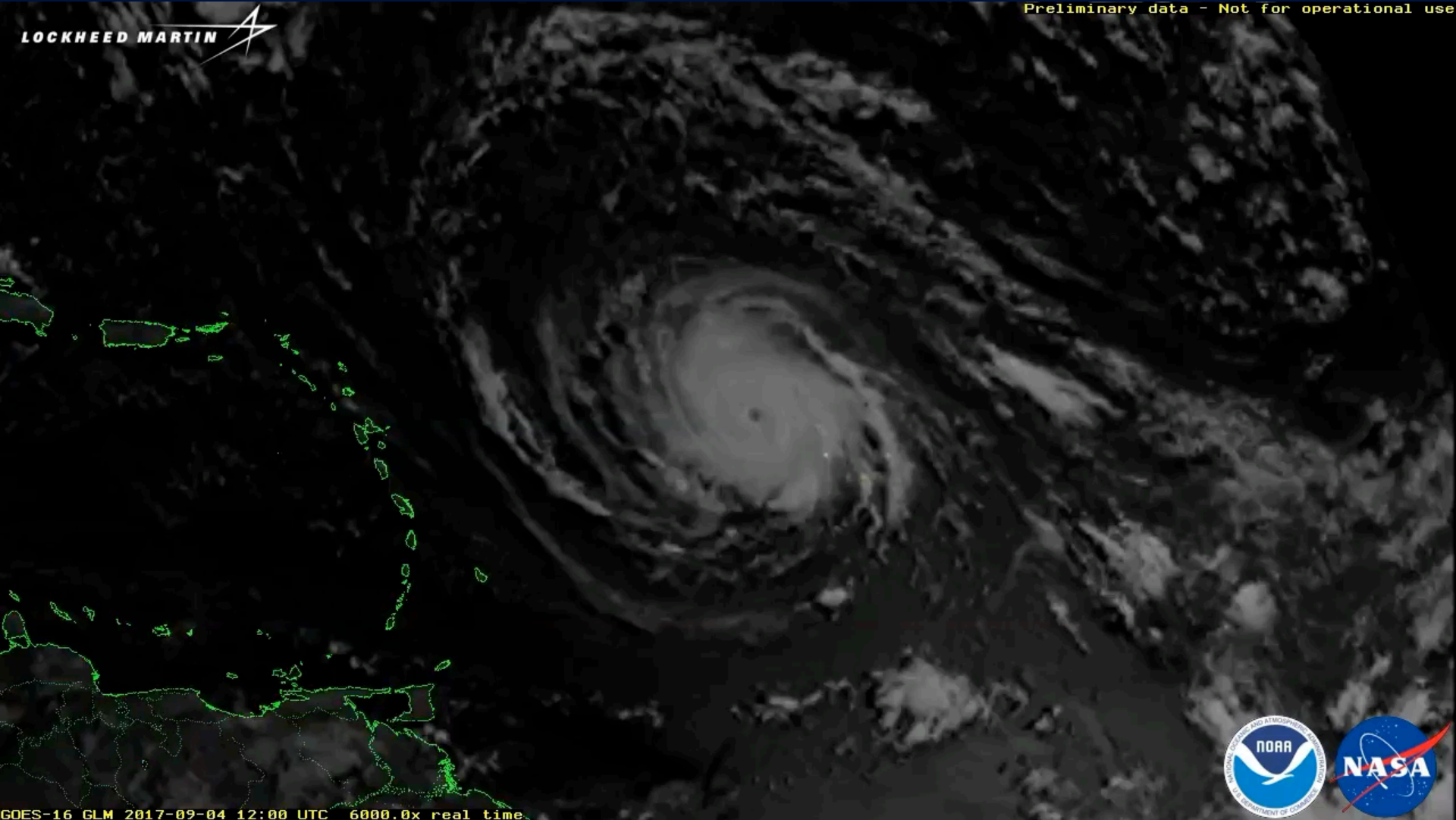


GOES-16 GLM 2017-04-28 18:00 UTC 6000.0x real time

Hurricane Irma 9/4 – 9/7, 2017

LOCKHEED MARTIN

Preliminary data - Not for operational use



GOES-16 GLM 2017-09-04 12:00 UTC 6000.0x real time



How to see these Videos

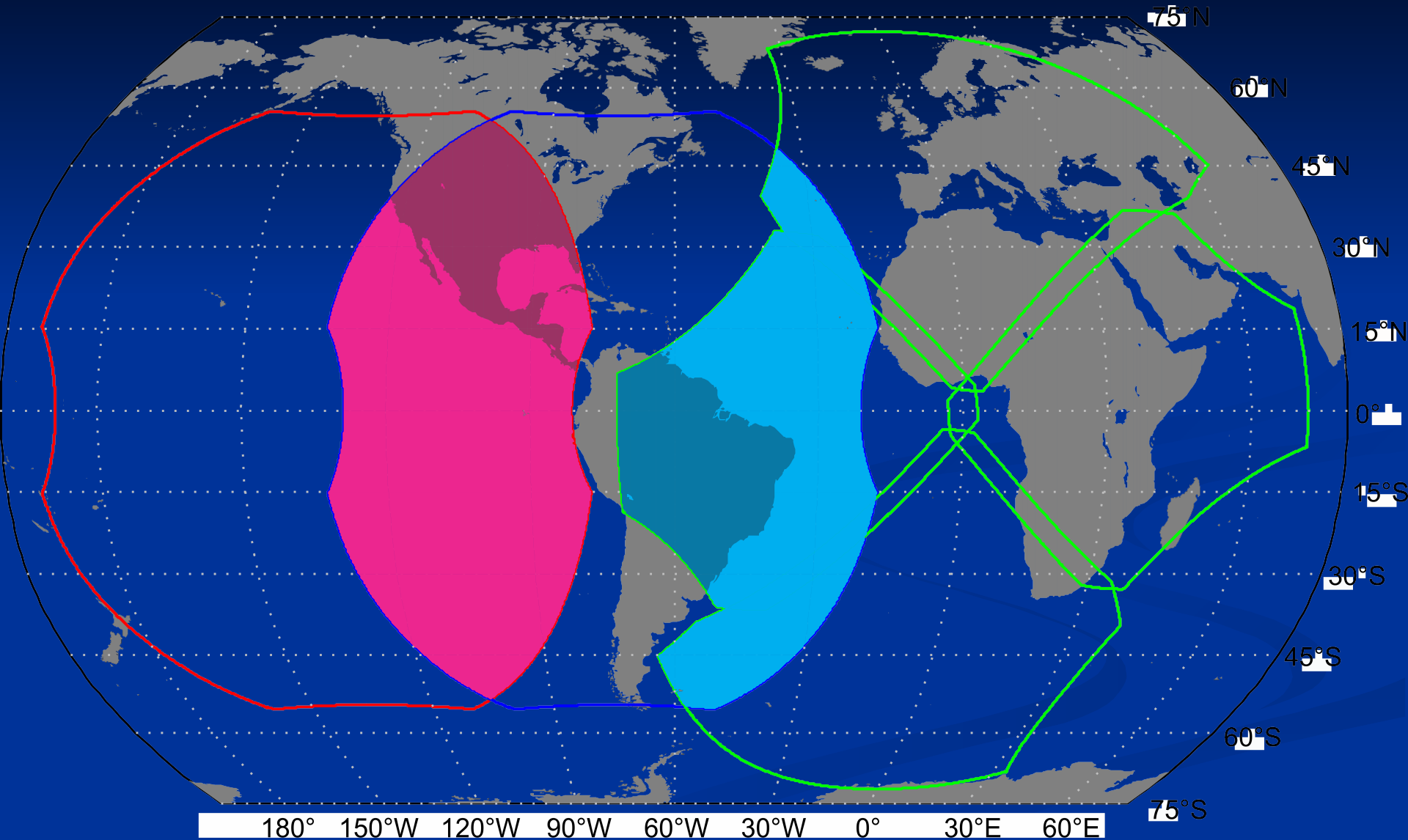
On YouTube.com, search for:
GLM Lockheed

Several videos are posted there.

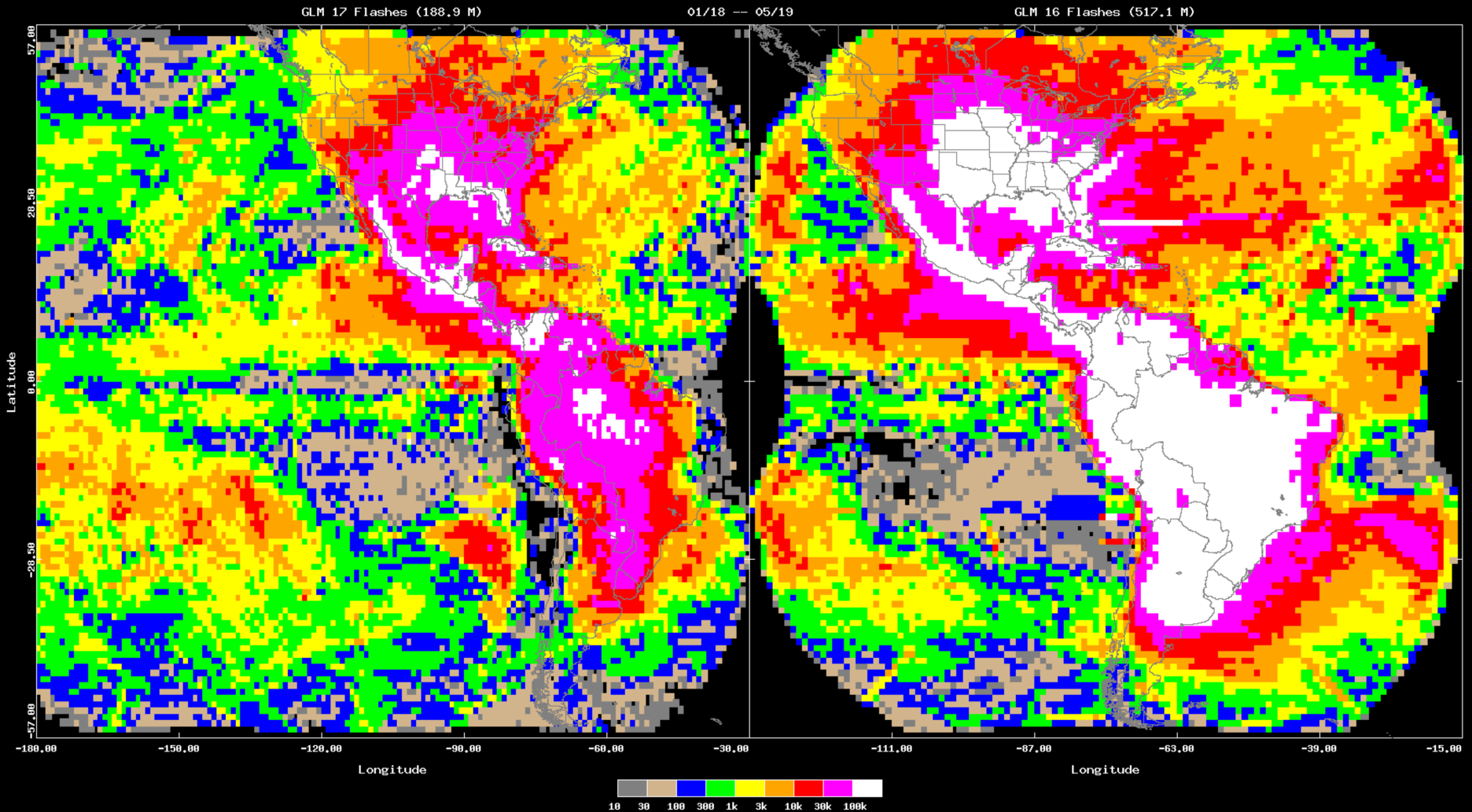
GOES-S (17)



Ltg Mapper Footprints



GLM Data



UWB Data Acquisition

- COTS A/D parts that can digitize into the GHz
- Made for 10Gbps+ ethernet
- Use this part and a high-bandwidth FPGA
- Anyone have experience with high-speed signal processing cores?
- Teach core how to “find” lightning signal and save those data; reject all else
- Like a spam filter

Lightning Spectra

- All measured lightning spectra stops with the instrument
- Lightning is a “black-body” radiator
- Radiation is caused by accelerating charge
- Lots of radiation in the VHF (leader pulses)
- Lots more fine-scale (fractal) that has to radiate into the GHz

Questions?



monte.bateman@uah.edu
Lightninganswers.com
Hamfest.org